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(71)Applicant : SEIKO EPSON CORP

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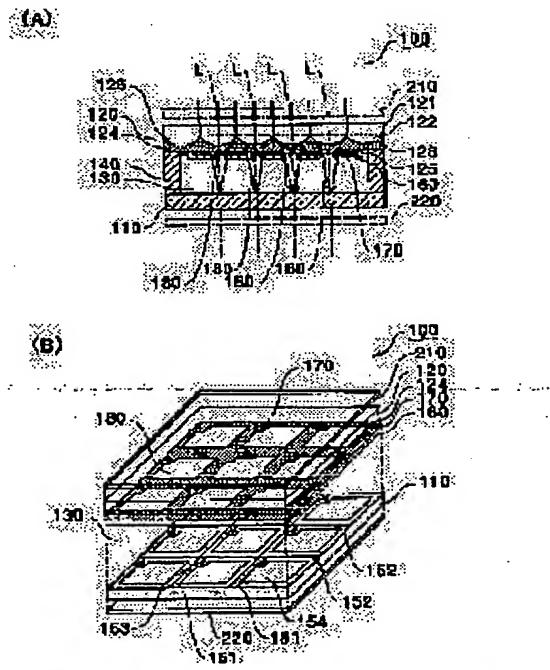
(72)Inventor : HASHIZUME TOSHIAKI

## (54) LIQUID CRYSTAL DEVICE AND PROJECTION DISPLAY DEVICE

### (57)Abstract:

**PROBLEM TO BE SOLVED:** To provide a constitution capable of enhancing an effective opening ratio efficiently and also capable of making a device thinner in a liquid crystal display device in which a microlens array is formed.

**SOLUTION:** In a liquid crystal device 100, a second substrate 120 in one pair of substrates 110, 120 holding a liquid crystal device 130 is provided with a microlens substrate 121 in which a microlens array 122 is formed on a light emitting surface 126. A light emitting surface 125 of the second substrate 120 is flattened by a resin layer 124 formed on the surface of the microlens array 122 to face a liquid crystal layer 130 through the resin layer 124. By this constitution, the effective opening ratio of the device can be enhanced by collecting lights efficiently to pixel openings 180 and also the miniaturizing and the thinning of the device can be achieved.



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CLAIMS

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[Claim(s)]

[Claim 1] It is liquid crystal equipment which it has two or more pixels arranged in the shape of a matrix, and it is liquid crystal equipment by which the liquid crystal layer was pinched with the substrate of a pair, and said one substrate is equipped with the micro-lens substrate with which the micro-lens array was formed in the field by the side of said liquid crystal layer, and is characterized by flattening of the field by the side of said liquid crystal layer of one [ said ] substrate being carried out by the resin layer formed in the front face of said micro-lens array.

[Claim 2] It is liquid crystal equipment characterized by said resin layer being resin of a photo-curing mold in claim 1.

[Claim 3] Liquid crystal equipment characterized by the thing of said micro-lens substrate for which the antireflection film is formed in the field of the opposite side with said liquid crystal layer at least in claims 1 or 2.

[Claim 4] It is the projection mold display which has a modulation means to modulate the flux of light by which outgoing radiation was carried out from the light source, and the projection means which carries out expansion projection of the flux of light modulated by the modulation means concerned on a projection side, and is characterized by said modulation means being liquid crystal equipment given in claim 1 thru/or one term of 3.

[Claim 5] A color separation means to separate into the flux of light of each color the flux of light by which outgoing radiation was carried out from said light source in claim 4, Said two or more modulation means to modulate the flux of light of each color separated by the color separation means concerned, The projection mold display characterized by carrying out expansion projection of the flux of light which has a color composition means to compound the flux of light of each color modulated as the modulation means concerned be alike, respectively, and was compounded by the color composition means concerned on a projection side with said projection means.

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DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the liquid crystal equipment with which improvement in an effective numerical aperture is achieved using the micro-lens array, and the projection mold display with which this liquid crystal equipment was incorporated.

[0002]

[Description of the Prior Art] In recent years, the projection mold display using liquid crystal equipment attracts attention, and this reason is that it can obtain a high-definition big image easily if the image of small liquid crystal equipment is projected on a screen etc., although it is very difficult to attain big screen-ization with the liquid crystal equipment of a direct viewing type. To use liquid crystal equipment for a projection mold display, it is necessary to increase the number of pixels so that granularity may not be conspicuous in image quality with a high dilation ratio. If the number of pixels is increased, with liquid crystal equipment, the area of parts other than a pixel will also increase in connection with it. Especially, with the liquid crystal equipment of a active-matrix mold, the inclination is strong. Parts other than a pixel are shaded in the protection-from-light layer generally called a black matrix, and the area of the part (opening) which is not shaded decreases. Consequently, the amount of the light by which outgoing radiation is carried out from the liquid crystal equipment made minute will decrease very much, and a display image will become dark.

[0003] In order to prevent the fall of the quantity of light accompanying minute-izing of liquid crystal equipment, a micro lens is attached in liquid crystal equipment, and the liquid crystal equipment of a configuration of having made it condense light to opening of each pixel by this micro lens is proposed.

[0004] The outline cross-section configuration of this liquid crystal equipment is shown in drawing 3. As shown in this drawing, liquid crystal equipment 200 has the opposite substrate 210 equipped with the glass substrates 211 and 212 of a pair mutually stuck by adhesives 230, and has the composition that laminating arrangement of this opposite substrate 210 was carried out through the liquid crystal layer 130 at the transparency substrate 220. The micro-lens array 213 which consists of two or more micro lenses corresponding to each pixel is formed in the field by the side of the liquid crystal layer in the glass substrate 211 of the outside of the opposite substrate 210.

[0005] Since a part for Mitsunari usually interrupted by the black matrix 170 can be condensed to the pixel opening 180 which corresponds by the micro-lens array 213 according to such liquid crystal equipment 200, a substantial numerical aperture can be improved and a bright display image can be obtained.

[0006]

[Problem(s) to be Solved by the Invention] As mentioned above, liquid crystal equipment is asked for their being small and a thin shape while the brightness of an image and highly minute-ization are called for. If a micro-lens array is formed, it is possible to attain the brightness of an image and highly minute-ization, but since the thickness of an opposite substrate increases, small and thin shape-ization cannot be attained.

[0007] The technical problem of this invention is in view of the above-mentioned point by aiming at efficiently thin-shape-izing of equipment, and improvement in an effective numerical aperture in the liquid crystal equipment with which the micro-lens array was formed to offer the liquid crystal equipment which can obtain a small display image bright enough. Moreover, it is in offering the projection mold display with which this liquid crystal equipment was incorporated.

[0008]

[Means for Solving the Problem] In order to solve the above-mentioned technical problem, the liquid crystal equipment of this invention It is liquid crystal equipment equipped with two or more pixels arranged in the shape of a matrix by which the liquid crystal layer was pinched with the substrate of a pair. Said one substrate It has the micro-lens substrate with which the micro-lens array was formed in the near field of said liquid crystal layer, and the near field of said liquid crystal layer of one [ said ]

substrate is characterized by flattening being carried out by the resin layer formed in the front face of said micro-lens array.

[0009] Thus, with the liquid crystal equipment of constituted this invention, since flattening of the front face of a micro-lens array has been carried out by the resin layer, it can change into the condition that the micro-lens array and the liquid crystal layer faced through the resin layer, and the substrate (glass substrate) by the side of the liquid crystal layer of conventional liquid crystal equipment (refer to drawing 3 ) can be excluded. Although it becomes the factor whose thickness of equipment increases in that the micro-lens array is formed, since the thickness of a glass substrate is very large compared with the thickness of a micro-lens array, if it carries out from the point that the glass substrate is removed, small [ of the liquid crystal equipment with which the micro-lens array was formed ], and thin shape-ization can be attained. Moreover, since distance from a micro-lens array to a liquid crystal layer can be shortened very much, the diameter of an optical spot in pixel opening can be extracted using the micro lens with a short focal distance according to the distance concerned. Therefore, light can be efficiently drawn to pixel opening, without being shaded by the black matrix. So, an effective numerical aperture can be raised efficiently and a display image bright enough can be obtained. Furthermore, since polish etc. can adjust the thickness of a resin layer easily, according to the focal distance of a micro lens, it is easy to adjust the distance from a micro-lens array to a liquid crystal layer to the desired die length.

[0010] As a resin layer, it can constitute from resin, such as epoxy of a photo-curing mold or a heat-curing mold, and an acrylic. Generally, since the setting time is short compared with the resin of a heat-curing mold, if it carries out from a viewpoint of mass-production nature, it is desirable [ the resin of a photo-curing mold ] to use the resin of a photo-curing mold. Moreover, a coefficient of thermal expansion chooses the thing near the glass generally used for the substrate of liquid crystal equipment, and the problem of peeling or the crack of resin by generation of heat accompanying an optical exposure is not produced.

[0011] In this invention, if the antireflection film is formed in the field of the opposite side, since reflection of the light in the field can be prevented, a liquid crystal layer at least is effective in respect of [ which gathers use effectiveness for light ] said micro-lens substrate.

[0012] The liquid crystal equipment of this invention can be used as said modulation means of the projection mold display which has a modulation means to modulate the flux of light by which outgoing radiation was carried out from the light source, and the projection means which carries out expansion projection of the flux of light modulated by the modulation means concerned on a projection side. A high-definition image small [ the projection mold display equipped with this liquid crystal equipment ], since improvement in small [ of equipment ], thin-shape-izing, and an effective numerical aperture is efficiently achieved in spite of forming the micro-lens array, as the liquid crystal equipment of this invention was mentioned above, and bright can be projected.

[0013] A color separation means to separate into the flux of light of each color especially the flux of light by which outgoing radiation was carried out from the light source, Two or more modulation means to modulate the flux of light of each color separated by this color separation means, The liquid crystal equipment of this invention is suitable as a modulation means of a projection mold display to have a color composition means to compound the flux of light of each color modulated by these modulation means, respectively, and the projection means which carries out expansion projection of the flux of light compounded by this color composition means on a projection side.

[0014]

#### [Embodiment of the Invention]

(Liquid crystal equipment) An example of the liquid crystal equipment which applied this invention to below with reference to the drawing is explained. The outline configuration of the liquid crystal equipment is shown in drawing 1 (A) and (B) using the sectional view and the perspective view. As shown in drawing 1 (A) and (B), the liquid crystal equipment 100 of this example has the 1st substrate 110 which is a glass substrate which consists of quartz glass etc., and the 2nd substrate 120 arranged

so that the 1st substrate 110 may be counteracted through a sealant 140, and has the structure where the liquid crystal layer 130 was enclosed among these substrates. The liquid crystal equipment 100 of this example is used for an optical optical plane-of-incidence and outgoing radiation side side as a light valve of a projection mold indicating equipment with the gestalt which has arranged the polarizing plate 210,200.

[0015] The 1st substrate 110 is a glass substrate which consists of quartz glass etc., and the source line 151 and the gate line 152 are formed in the front face in the shape of a grid. The thin film transistor (TFT) 153 is connected to the source line 151 and the gate line 152. The transparent pixel electrode 154 is connected to the thin film transistor 153 at the serial.

[0016] The 2nd substrate 120 is equipped with the micro-lens substrate 121 formed from the glass ceramics which consist of a quartz, neo SERAMU, etc., and the micro-lens array 122 is formed in the near field (optical outgoing radiation side) 126 of the liquid crystal layer 130 of this micro-lens substrate 121.

[0017] The micro-lens array 122 consists of two or more micro lenses 123. Each micro lens 123 is a convex lens, and is arranged in the shape of a matrix corresponding to each pixel of the 1st substrate 110. Moreover, the optical property is given so that the light which passed along the resin layer 124 mentioned later may condense each micro lens 123 to the pixel opening 180. For this reason, it is brought together in each pixel opening 180 of the light which carried out incidence to the macro lens array 122 to which all almost correspond according to a condensing operation of the micro-lens array 122, and the amount of the light which passes the pixel opening 180 can be increased.

[0018] After carrying out patterning so that the micro-lens array 122 of the request to the micro-lens substrate 121 may be obtained in order to form the micro-lens array 122 in the micro-lens substrate 121 for example, it can form by the photolithography method. Moreover, the micro-lens array 122 can also be formed by shaving a material by the machining method. Furthermore, forming with vacuum deposition etc. is also possible. In this case, what is necessary is to vapor-deposit the predetermined matter until it forms the same crevice as the profile configuration of a micro lens 123 on the substrate and fills up with this crevice, and for polish etc. just to adjust the whole thickness (thickness of the part used as the micro-lens substrate 121) after that. In addition, of course, the micro-lens array 122 may be formed from an ingredient which is different in the micro-lens substrate 121.

[0019] In the liquid crystal equipment 100 of this example, flattening of the resin layer 124 is formed and carried out to the front face of the micro-lens array 122. After this resin layer 124 forms the micro-lens array 122, it can apply adhesives to the front face of the micro-lens array 122 concerned, and can form them by carrying out flattening of that front face, and hardening it. At this time, it is desirable to form the resin layer 124 of the thickness which is extent which the irregularity by the micro-lens array 122 does not produce.

[0020] The adhesives of the photo-curing mold hardened by light, such as ultraviolet rays, and the adhesives of the heat-curing mold hardened with heat can be used for the resin layer 124. In addition, it is more advantageous to adopt adhesives, such as epoxy of a photo-curing mold, an acrylic, and silicon, from a heat-curing mold, when the setting time is taken into consideration, since the adhesives of a photo-curing mold can be stiffened from the adhesives of a heat-curing mold for a short time. Since silicon adhesives have high elasticity, even if thermal stress arises in the difference in a coefficient of thermal expansion with glass, they have the merit which can absorb the stress. Moreover, a coefficient of thermal expansion chooses the thing near the glass generally used for the substrate of liquid crystal equipment, and the problem of peeling or the crack of resin by generation of heat accompanying an optical exposure is not produced.

[0021] In addition, it is necessary to make the refractive index of the resin layer 124 smaller than the refractive index of the micro-lens substrate 122.

[0022] What is necessary is just to use fluid high adhesives for example comparatively, in order to form the flat resin layer 124. Moreover, what is necessary is just to apply adhesives to the micro-lens array

122 with the so-called spin coat method which applies adhesives, carrying out high-speed rotation of the micro-lens substrate 121.

[0023] Furthermore as an option, adhesives are first applied to the front face of the micro-lens substrate 121. Next, the flattening member which performed surface treatment which adhesives do not attach to the front face as for which flattening was carried out by polish etc. is laid on the adhesives. Next, a flattening member and the micro-lens substrate 121 are printed, and flattening of the front face of adhesives is carried out. If adhesives are stiffened and a flattening member is finally removed, the resin layer 124 by which flattening was carried out will be formed. It is desirable to be formed from the ingredient which has light transmission nature as a flattening member used at this time, and if such a flattening member is used, when the adhesives of a photo-curing mold are used, optical exposure area can be enlarged, shortening of the setting time can be attained, and it is advantageous in respect of mass-production nature.

[0024] In order to prevent that light is irradiated by the switching element currently formed in the 1st substrate 110, the black matrix 170 which consists of a chromium metal etc. is formed in the front face of the resin layer 124 of the micro-lens substrate 121 of vacuum evaporation etc. By this black matrix 170, hardening of prevention of the photodegradation of a switching element, prevention of the leakage light between pixels, etc. is obtained, and the bright high display image of contrast can be obtained. Moreover, the counterelectrode 160 is formed in the front face of the resin layer 124.

[0025] Thus, in the constituted liquid crystal equipment 100, the light L which carried out incidence to the micro-lens substrate 121 from the counter electrode side is refracted by each micro lens 123 of the micro-lens array 122, and condenses to the pixel opening 180 which corresponds through the resin layer 124. With the liquid crystal equipment 100 of this example, the resin layer 124 formed in the front face of the micro-lens array 122 faces with the liquid crystal layer 130, and it has become the gestalt from which the glass substrate 212 in the conventional liquid crystal equipment 200 which explained drawing 3 to reference was excluded.

[0026] For this reason, it is only that the resin layer 124 intervenes between the micro-lens array 122 and the liquid crystal layer 130, and distance from the micro-lens array 122 to the liquid crystal layer 130 can be shortened very much. Therefore, the micro lens 123 with a short focal distance according to the distance can be used, and it becomes possible to form a minute optical spot in the pixel opening 180. Consequently, without being interrupted by the black matrix 170, light can be efficiently collected to the pixel opening 180, an effective numerical aperture can be raised, and a display image bright enough can be obtained.

[0027] Moreover, although it becomes the factor whose thickness of equipment increases in that the micro-lens array 122 is formed, since the glass substrate of very large thickness is removed compared with the thickness of the micro-lens array 122, small [ of the liquid crystal equipment with which the micro-lens array 122 was formed ], and thin shape-ization can be attained.

[0028] In addition, with the liquid crystal equipment 100 of this example, although the micro-lens array 122 is formed in the micro-lens substrate 121 at one, the micro-lens array 122 is formed separately and the micro-lens array 122 may be joined to the micro-lens substrate 121 afterwards. Moreover, in order to raise efficiency for light utilization, it is desirable to form an antireflection film in the front face of the micro-lens array 122.

[0029] (Projection mold display) An example of the projection mold display equipped with the liquid crystal equipment which applied this invention is explained. The projection mold display of this example the white light bundle by which outgoing radiation was carried out from the light source lamp unit Red (R), It is the thing of the format which separates into green (G) and the blue (B) three-primary-colors flux of light, each of these colored light bundles are made to correspond to image information through the liquid crystal equipment which applied this invention as a light valve, modulates them, re-compounds the flux of light of each color after becoming irregular, and carries out an enlarged display on a screen through projection optical system.

[0030] The outline configuration of the optical system included in the projection mold display 1 of this example is shown in drawing 2. The homogeneity illumination-light study system 923 which has the light source lamp 80 which is the component of the light source lamp unit 8, and the 1st lens plate 921 and the 2nd lens plate 922 equipped with two or more rectangle lenses is adopted as the optical system of the projection mold display 1 of this example. And the color separation optical system 924 by which the projection mold display 1 separates into red (R), green (G), and blue (B) the flux of light W by which outgoing radiation is carried out from this homogeneity illumination-light study system 923. The liquid crystal equipments 100R, 100G, and 100B of three sheets which modulate each colored light bundles R, G, and B, It has the dichroic prism 10 as color composition optical system which re-compounds the colored light bundle after becoming irregular, and the projection lens unit 6 which carries out expansion projection of the compounded flux of light on the front face of a screen 1000. Furthermore, it has the light guide system 927 led to liquid crystal light valve 100B corresponding to the blue glow bundle B among each colored light bundles R, G, and B.

[0031] This homogeneity illumination-light study system 923 will carry out incidence of the outgoing radiation light from the light source lamp 80, it will be projected as secondary light source images, respectively on the plane of incidence of each rectangle lens which constitutes the 2nd lens plate 922 through the 1st lens plate 921, and the liquid crystal equipments 100R, 100G, and 100B which are illuminated objects will be irradiated using the outgoing radiation light from the 2nd lens plate 922 concerned.

[0032] In addition, the homogeneity illumination-light study system 923 is equipped with the reflective mirror 931, and it turns optical-axis 1a of the outgoing radiation light from the homogeneity illumination-light study system 923 to equipment front, and he is trying to bend it at a right angle. It is arranged at the condition that the 1st and 2nd lens plate 921 and 922 intersects perpendicularly on both sides of this reflective mirror 931.

[0033] The color separation optical system 924 consists of a bluish green reflective dichroic mirror 941, a green reflective dichroic mirror 942, and a reflective mirror 943. In the bluish green reflective dichroic mirror 941, the blue glow bundle B included there and the green light bundle G are first reflected mostly by the right angle, and the flux of light W goes to the green reflective dichroic mirror 942 side.

[0034] The bluish green reflective dichroic mirror 941 is penetrated, it is mostly reflected by the right angle by the back reflective mirror 943, and outgoing radiation of the red flux of light R is carried out to a dichroic prism 10 side from the outgoing radiation section 944 of the red flux of light R. In the green reflective dichroic mirror 942, the green light bundle G is mostly reflected by the right angle, and outgoing radiation of the blue and the green light bundles B and G which were reflected in the bluish green reflective dichroic mirror 941 is carried out to a dichroic prism 10 side from the outgoing radiation section 945 of the green light bundle G. Outgoing radiation of the blue glow bundle B which penetrated this green reflective dichroic mirror 942 is carried out to the light guide system 927 side from the outgoing radiation section 946 of the blue glow bundle B. In this example, it is set up so that all the distance from the outgoing radiation section of the flux of light W of a homogeneity illumination-light study system to the outgoing radiation sections 944, 945, and 946 of each colored light bundle in the color separation optical system 924 may become equal.

[0035] Condenser lenses 951 and 952 are arranged at the outgoing radiation side of the red of the color separation optical system 942, and the outgoing radiation sections 944 and 945 of the green light bundles R and G, respectively. Therefore, incidence of the red and the green light bundles R and G which carried out outgoing radiation from each outgoing radiation section is carried out to these condenser lenses 951 and 952, and they are made parallel.

[0036] Thus, incidence of the red and the green light bundles R and G which were made parallel is carried out to the liquid crystal equipments 100R and 100G, they are modulated, and the image information corresponding to each colored light is added. That is, according to image information, switching control of these liquid crystal equipments is carried out by the non-illustrated driving means,

and, thereby, the modulation of each colored light which passes through this is performed. Such a driving means can use a well-known means as it is. On the other hand, the blue glow bundle B is led to liquid crystal equipment 100B which corresponds through the light guide system 927, and a modulation is similarly performed in here according to image information.

[0037] The light guide system 927 consists of a middle lens 973 arranged between the condenser lens 954 arranged to the outgoing radiation side of the outgoing radiation section 946 of the blue glow bundle B, the incidence side reflective mirror 971, the outgoing radiation side reflective mirrors 972, and these reflective mirrors, and a condenser lens 953 arranged to the near side of liquid crystal equipment 100B. The blue glow bundle B becomes the longest, therefore the quantity of light loss of this flux of light of distance from the optical path length 80, i.e., the light source lamp, of each colored light bundle to each liquid crystal panel increases most. However, quantity of light loss can be controlled by making the light guide system 927 intervene.

[0038] Next, each colored light bundles R, G, and B modulated through each liquid crystal equipments 100R, 100G, and 100B are re-compounded with a dichroic prism 10. Expansion projection of the color picture compounded with this dichroic prism 10 is carried out on the front face of the screen 1000, which is in a position through the projection lens unit 6.

[0039] Thus, the constituted projection mold display 1 is equipped with the liquid crystal equipments 100R, 100G, and 100B which applied this invention. Since the effective numerical aperture is raised as mentioned above, the liquid crystal equipments 100R, 100G, and 100B can project a bright high-definition image with the projection mold display 1 equipped with these liquid crystal equipments 100R, 100G, and 100B. Moreover, since the liquid crystal equipments 100R, 100G, and 100B can be small constituted thinly compared with conventional liquid crystal equipment in spite of forming the micro-lens array 122, they can offer the projection mold display of compact size with the projection mold display 1 equipped with these liquid crystal equipments 100R, 100G, and 100B.

[0040] Although the projection mold display 1 which is [the gestalt of other operations] and which was mentioned above is a front projection mold display which performs projection from the side which observes a projection side, it can apply the liquid crystal equipment of this invention also to the tooth-back projection mold display which performs projection from a direction opposite to the side which observes a projection side.

[0041] Moreover, the liquid crystal equipment 100 mentioned above can be used also as liquid crystal equipment of a direct viewing type.

[0042]

[Effect of the Invention] He carries out flattening of the front face of a micro-lens array by the resin layer, and is trying to be in the condition that the micro-lens array and the liquid crystal layer faced through this resin layer, with the liquid crystal equipment of this invention, as explained above. Therefore, since the substrate with bigger thickness (glass substrate) than a micro-lens array is excluded compared with conventional liquid crystal equipment, small [ of the liquid crystal equipment with which the micro-lens array was formed ], and thin shape-ization can be attained. Moreover, since distance from a micro-lens array to a liquid crystal layer can be shortened, according to the distance concerned, the focal distance of a micro lens can also be shortened and can form a minute optical spot in pixel opening. For this reason, since light can be efficiently drawn to pixel opening, without being shaded by the black matrix, an effective numerical aperture increases and a display image bright enough can be obtained.

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## DESCRIPTION OF DRAWINGS

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### [Brief Description of the Drawings]

[Drawing 1] The outline cross-section block diagram of the liquid crystal equipment with which (A) applied this invention, and (B) are the perspective views of the liquid crystal equipment.

[Drawing 2] It is the outline block diagram showing the optical system of the projection mold display with which the liquid crystal equipment shown in drawing 1 was incorporated.

[Drawing 3] It is the outline cross-section block diagram of conventional liquid crystal equipment.

### [Description of Notations]

1 Projection Mold Display

6 Projection Lens Unit

80 Light Source Lamp

10 Dichroic Prism

100,100R, 100G, 100B Liquid crystal equipment

110 1st Substrate

120 2nd Substrate

121 Micro-Lens Substrate

122 Micro-Lens Array

123 Micro Lens

124 Resin Layer

125 Optical Outgoing Radiation Side of 2nd Substrate

126 Optical Outgoing Radiation Side of Micro-Lens Substrate

130 Liquid Crystal Layer

140 Sealant

151 Source Line

152 Gate Line

153 Thin Film Transistor (TFT)

154 Pixel Electrode

160 Counterelectrode

170 Black Matrix

180 Pixel Opening

210 220 Polarizing plate

921, 922 Integrator lens

923 Homogeneity Illumination-Light Study System

924 Color Separation Optical System

1000 Projection Side

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[Translation done.]